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Department of Geodetic Science and Surveying

Development of Improved Gravity Field Estimates Using Existing Altimeter Data

Status Report No. 2

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1. Introduction

The work being performed under this grant is directed towards the improvement of our knowledge in the behavior of orbit errors in satellite altimetry and towards the optimum determination of sea surface and sea surface topography with the simultaneous reduction of the orbit errors.

This status report will cover activities spanning the time period from November 1, 1985 to December 31, 1986. These activities are a continuation of the work described in the previous status report submitted to Goddard Space Flight Center in November of 1985 and covering the period from April 1, 1985 to October 31, 1985. In that report the formulation of a Fourier series and geographic representation expressions for the orbit error had been reported. Additional activities included the study of undulation errors in the Lagrangean formulation, and the development and testing of all the necessary software for the above expressions. Additionally the matrix formulations that led to the formation of observation equations and covariance propagation had been developed during that period.

2. The current status of the research effort

The research effort since November of 1985 has heavily concentrated on the determination of statistical estimates of the orbit and undulation errors and on the estimation of potential coefficient corrections and sea surface topography parameters that lead to the determination of the sea surface and sea surface topography.

The work started with the development and testing of a complete software to compute variances and correlations of the orbit and undulation errors with respect to time as well as with respect to geographic coordinates. In both cases, a full covariance matrix of the geopotential was considered for the propagation. The software is set up to work up to any maximum harmonic degree limited only by computer resources. In the case of geographic representation, variances and correlations of ascending and descending arcs, and also of the constant and variable parts of the error can be computed. The usefulness of such an implementation is obvious since one can determine the statistical properties of the errors before and after their determination.

For the development of the observation equations the parameterization of sea surface topography was required. A spherical harmonic representation is used for that matter. This expression was converted to a Lagrangean form and is identical to the one for undulation errors.

Using the models developed for all quantities of interest complete observation equations have been developed. These equations use as observables either sea surface heights or crossover discrepancies. Both sets of equations are linearized expressions having as unknowns the harmonic coefficients of sea surface topography and potential coefficient correction to the gravity field used for the orbit determination. The main problem in the solution of the observation equations is the separability of the sea surface topography coefficients from the potential coefficient corrections when the sea surface heights are used as observables. That separability can be achieved by using prior information for the parameters. A reliable covariance matrix

for the gravity field and estimates of the power spectrum are needed for this purpose. The initial values that are used for the undulation signal are the ones generated by the above mentioned gravity field. This creates omission errors that contaminate the solution. So a study has been performed to determine the cumulative magnitude of those effects. More work has to be performed for the systematic treatment of the higher degree undulation signature.

The above estimation technique has been tested using synthetic data. Using the full covariance matrix of the PGSS4 gravity field up to maximum harmonic degree 10, random deviates have been generated to represent potential coefficient errors. The Levitus harmonic coefficients were used to represent the sea surface topography. With those two sets of coefficients orbit errors, undulation errors and sea surface topography estimates have been computed. These estimates have been used, together with a random noise of 10 cm to account for the altimeter noise, to generate the observables for both sea surface heights and crossover discrepancies, for a three day SEASAT arc. A solution using the PGSS4 covariance matrix yielded coefficients which were further used to generate orbit errors, undulation errors and sea surface topography. It turns out , after comparison with the original quantities, that over 85% of the orbit error and sea surface topography can be estimated, while the undulation error can be reduced by a factor of two. Propagation of the a posteriori covariance matrix gave variances consistent with the magnitudes of the residual quantities.

The solution has been repeated using the PGSS4 covariance matrix scaled by a factor of 10 (with a similar scaling in the simulated potential coefficient errors). The solution indicated no significant degradation of the results. Several more solutions have been performed using as potential ccoefficient corrections the differences between GEM9 and GEM10B, GEML2 and GRIM3L1 and others, always using different types of prior information or no information at all. In all cases the results were not acceptable primarily because of the inconsistency, or non existence, of prior information with the potential coefficient corrections that were considered. This fact shows the extreme sensitivity of the system to the correct choice of prior information.

3. Proposed effort for the remaining period of the grant.

Having been able to successfully recover all quantities of interest in our test simulated solution and show its sensitivity under different conditions, we feel that we have completed many of the tasks that we initially proposed. Nevertheless substantial work is still remaining. A very important aspect of the research work is an extensive validation of the analytic theory and a comprehensive review of all the procedures developed up to now to further improve and or correct methods and software wherever and if necessary.

The validation of the analytic theory has started in mid December of 1986 and is not completed as of the time of the writing of this report. It consists of comparing analytically computed orbit errors with the ones generated by differencing two numerically integrated orbits using GEM9 and GEM10B.

A very important task is the preparation of the final report that will document all the details of the work. Finally it is mandatory that a systematic

documentation of all the computer programs be prepared.

At this time, it cannot be anticipated in a realistic manner that everything can be prepared on time by March 31, 1987 the current ending date of the contract.

4. Reports and Presentations

During this reporting period, Mr. Engelis has made the following presentations:

Modeling of Radial Orbit Errors in Satellite Altimetry, presented at the TOPEX Gravity Modeling Team Meeting, University of Texas at Austin, April 1986.

Orbit Error Reduction and SST Determination Using Satellite Altimetry, presented at the TOPEX Gravity Modeling Team Meeting, NASA, Goddard Space Flight Center, Greenbelt, MD, November 1986.

Orbit Error Reduction and Determination of Sea Surface Topography Using Satellite Altimetry, presented at the AGU Fall Meeting, San Francisco, December 1986.

5. Other

Mr. Engelis attended the Fourth International Summer School in the Mountains at Admont, Austria, in August of 1986. At this meeting he presented his studies on altimeter analysis.